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PULP AND NEWS-PAPER MANUFACTURE

By J. STADLER

To be read before a Monthly Meeting, March 5th, 1914

The subject of this paper is the power consumption in the manufacture of news-paper, and in the production of the fibre for the making of the paper, that is, the ground-wood and sulphite process.

The fibre used in the making of news-paper is produced entirely from wood. The wood used is principally spruce, hemlock and balsam. The other coniferous woods are used in smaller quantities.

News-paper is usually manufactured from 75% mechanical pulp (ground-wood) and 25% chemical pulp (sulphite pulp). Under ordinary conditions one cord of wood is required to make one ton of ground-wood, and two cords of wood are required to make one ton of sulphite pulp; hence for the production of news-paper one and a quarter cords of wood are used for every ton of news-paper made.

That Canada may be classified as a papermaking country can be seen from the following figures:—

	Daily Production	Production in tons per annum	Value of Product (Dollars)	Daily H.P. required per 24 hrs.
Mechanical Pulp.....	3,180 tons	800,000	12,400,000	210,000
Chemical Pulp.....	905 tons	272,000	10,336,000	7,500
News-paper	1,580 tons	480,000	18,240,000	20,000

In addition to the above, Canada is producing large quantities of chemical pulp made by the sulphate and the soda processes, from which

paper is made under the classes of Kraft, packing, book and writing papers; these papers, however, will not be considered here.

From the above it will be seen that in the news-paper industry there is a daily output of 237,500 H.P., of which the principal amount is used in the production of mechanical pulp.

A number of ground-wood mills do not operate the entire year round to full capacity for lack of motive power.

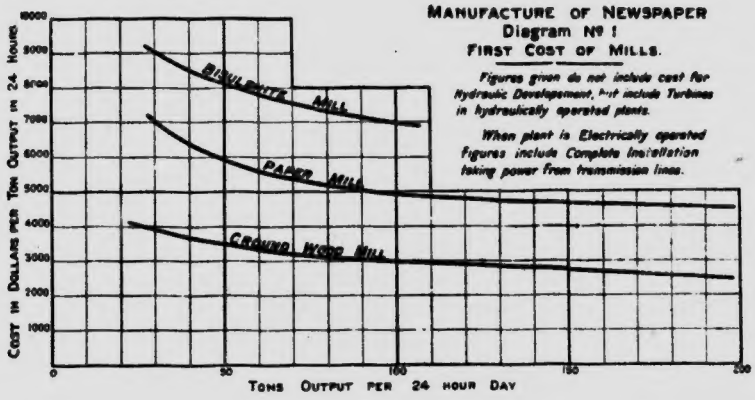
The power requirements per ton of finished product may be taken as follows:—

Mechanical Pulp 1,200 to 1,920 H.P. hours=50 to 80 H.P. per 24 hours.

Sulphite Pulp 144 to 240 H.P. hours=6 to 10 H.P. per 24 hours.

News-paper 252 to 384 H.P. hours=10.5 to 16 H.P. per 24 hours.

The costs of plants are shown in diagram No. 1 and the figures are based on modern installations built to manufacture at lowest cost.



The writer is of the opinion that the heretofore prevailing custom of building plants for the paper industry with a view to low first cost will be discontinued as such plants do not manufacture economically.

In the paper industry, like any other industry where motive power is used, constant speed is of importance, yet where a number of plants have been visited it is found that little has been done to provide this very important condition in the operation of the machinery employed. Investigations made have demonstrated that speed variations influence the quality and quantity produced to a very great extent and because of its easy application and constant speed, electric power is becoming more used in the news-paper and other industries.

Manufacturers of paper mill machinery should give more attention to the construction of machinery for direct connected electric drive, as generally the power required by the different machines is of such magnitude that machines may be operated in such a manner very efficiently.

The Mechanical Pulp or Ground-wood Plant

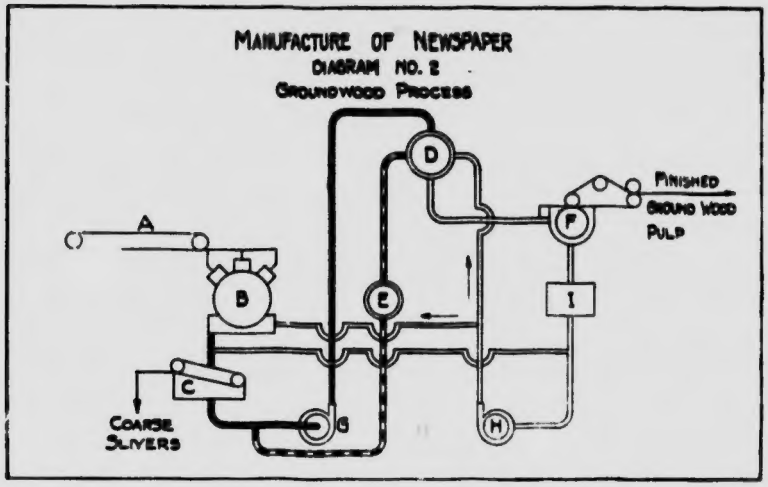
It is only within the past few years that ground-wood pulp mills have been located remote from water power, and have used electrical energy for their operation.

In view of the large amount of power required, the location of such mills must be at places where low-priced power is available.

The ground-wood process may be briefly followed by referring to Diagram No. 2, in connection with the following table:—

Apparatus	Approx. H.P. hours required per ton Air Dry Pulp	Approx. ratio of product to water	Performance of Apparatus
A. Conveyors.....	2 to 6		Delivering wood to plant.
B. Grinder.....	1025 to 1596		Grinding solid wood to fibre.
C. Coarse Screen..	3 to 6	1:350	Separating coarse slivers from fibre.
D. Fine Screen....	36 to 60	1:350	Separating fine fibre from coarse fibre.
E. Refiner.....	50 to 100	1:20	Reducing coarse fibre to fine fibre.
F. Wet Machine..	30 to 50	1:3	Separating water from fine fibre.
G. Pump.....	24 to 60	1:350	Lifting pulp and water to required height.
H. Pump.....	20 to 40	....	Lifting clear water to spray pipes.
I. Cooler.....	.....	....	To absorb heat produced at "D."
Total.....	1200 to 1920 or from 50 to 80 H.P. per ton on 24 hr. power.		

N.B.—Cooler is only given to show ideal installation in actual practice. Sufficient fresh water is supplied to keep temperature within desirable limits; the surplus water thus introduced in the process is generally permitted to run to waste, which quite often causes an appreciable loss of fine fibre.



The writer is of the opinion th[illegible] th[illegible] future ground-wood mills will be especially constructed with a [illegible] power from large hydro-electric plants at such hours of the d[illegible] ad is low, in order to raise the load factor of the power plant.

The progress made in the past fe[illegible] years with automatic pulp grinders facilitates such an installation. In order, however, to keep the investment as low as practicable, the writer would propose to operate the auxiliary machinery of such a plant for twenty-four hours, and the grinders which absorb the bulk of the power for about 12 hours per day. A plant running only part of the year would not give steady employment to the help needed, and would, therefore, lead to inefficiency in operation. Such a ground-wood mill could, however, be operated as an individual plant, but in connection with a paper mill a steady power for practically the whole year round would be essential. With this in view, the following has been prepared:—

Reference to Diagram No. 2, of ground-wood process, shows that operation "A" requires 2 to 6 H.P. hours.

Operation "B" requires 1,035 to 1,596 H.P. hours.

Operation "C" to "H" inclusive requires 162.5 to 316 H.P. hours.

Estimating on the construction of a plant making 30,000 tons per year, based on 300 operating days, or 100 tons per day, Item "A" would be operated in daytime only; Item "B" at night only; Items "C" to "H" during 24 hours.

The electric power is assumed at $16.00 per H.P. per annum, from 7 A.M. to 7 P.M.; at $8.00 per H.P., from 7 P.M. to 7 A.M., which figures at 0.22 cents and 0.11 cents per horse-power hour respectively.

As an alternative, take a plant operating 24 hours, except Item "A", which is operated during the day only, at a fixed power cost of $16.00 or 22 cents per horse-power hour:—

	No. 1—Full power, 12 hrs.			No. 2—24-hour power		
		per annum	per ton		per annum	per ton
6% interest on capital invested	$450,000	$27,000	$0.90	$300,000	$18,000	$0.60
10% depreciation on auxiliary equipment	100,000	10,000	.33	100,000	10,000	.33
6% depreciation on main equipment and buildings	350,000	21,000	.70	200,000	12,000	.40
Day power at 22 cents per hour	100 H.P. hours		.22	702.5 H.P. hours		1.55
Night power at 22 cents per hour			..	697.5 H.P. hours		1.53
Night power at 11 cents per hour	1,300 H.P. hours		1.43			..
Total cost per ton			$3.68			$4.41

P.S.—In the foregoing table it is assumed that 5 H.P. hours are required for "A"; 1,205 H.P. hours are required for "B"; 190 H.P. hours are required for "C" to "H."

The power requirements are taken low for a plant of that size, but any increase in power consumption would be more in favor of the low priced power.

It will be noticed that the plant No. 1 operates with about 830 H.P. load for 12 hours, and 10,800 H.P. for the other 12 hours, whereas plant No. 2 operates on a practically steady load of 5,850 H.P.

The resulting economy of plant No. 1 over No. 2 is 73 cents per ton on the power figures assumed. Pro rata computations can be made for any other power cost.

As already stated, the writer does not advise operating individual ground-wood plants for part of the year only. Such plants would become quite expensive, and the fixed charges per ton of product would be quite high; furthermore, ground-wood depreciates in value with age, and such a plant would have to store large quantities of ground-wood to supply the market as required.

Of the power employed in the news-paper industry 84.4 per cent. is used in ground-wood mills, 8.4 per cent. in paper mills, and 3.2 per cent. in sulphite mills. In the ground-wood mills 86 per cent. of the total power consumed is applied to grinding the wood, so that out of the total amount of power used in Canada in the manufacture of news-paper and its allied industries, 76 per cent. is used on the grinders.

By referring to photographs 1 and 2, an idea may be formed of the general arrangement of the pulp grinders of the ordinary type.

Photographs Nos. 3 and 4 show an installation of two automatic grinders. The ordinary grinders are generally arranged in such a way that one man can feed the wood into two machines which produce from six to nine tons each in 24 hours.

Pulp makers have usually believed that the speed at which the grinder operated was of no great consequence and that the determining factor was the pressure with which the wood was forced against the grindstone.

The writer has made numerous experiments, which have shown that with a grindstone running at a surface speed of from 3,200 to 3,500 feet per minute, the pressure may be varied within a large range without having any appreciable affect on the amount of fibre produced as long as the speed is kept reasonably constant. This also is confirmed by other experimenters.

A number of old plants are without speed control, and, as a result of the fact that the operator who attends to the grinder will not feed regularly, the product necessarily varies considerably. To illustrate this point, reference will be made to the performance of an ordinary grinder which was operated by a hydraulic turbine and to the gate mechanism of which was attached a Bristol Mechanical Recorder. The speed of this turbine was kept constant by a governing device and the movement shown by the recorder represents the gate opening of the turbine which is nearly proportional to the power. The record is for a 24 hours run, and the shifts of operators were made at 7.00 a.m., 3.00 p.m., and 11.00 p.m., respectively. It will be noted that the least efficiency was obtained between 11.00 p.m. and 7.00 a.m., a fact which might be attributed to the work being done at night, but which was in reality due to the inexperience of the operator, who was a new man.

This chart is specially shown with a view to calling attention to the manual expertness of operators, and to point out how necessary it is that plants, even of this nature, be kept in operation the whole year in order that the operators may obtain a higher degree of efficiency.

The writer has given preference to automatic grinders, especially when they are electrically driven and in use for part of the day only.

Automatic grinders can be adjusted in such manner that practically no manual attention is necessary, and, for this reason, the efficiency of such a machine should be considerably in excess of what can be obtained with the ordinary type of grinder.

By referring to photograph No. 3, which shows the charging end of an automatic grinder, it will be noted that the receptacle over the grinder contains a large quantity of wood and installations have been made where the wood supply in these automatic grinders lasts from 12 to 16 hours. Such machines are specially adapted for use when surplus electrical power is available at any time of the day. Actual operating results have shown that the amount of pulp produced per H.P. hour is from 10 to 20 per cent.

in excess of what has been possible with the ordinary type of grinders; and the automatic machines have the further advantage that one skilled operator can supervise a number of them, the duty of the operator being only to see that the mechanism is kept in good working order.

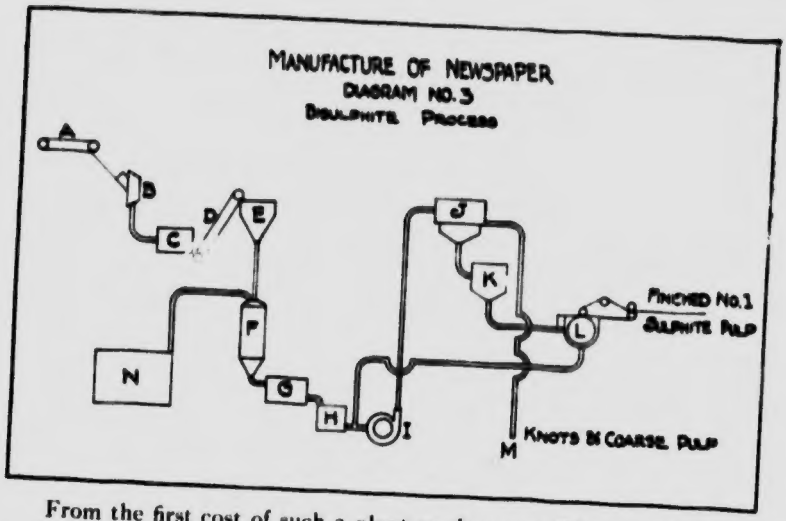
In order to avoid misunderstanding, it should perhaps be stated that such devices for constant power consumption can be and are used on the ordinary grinder, and to repeat that so long as the placing of the wood to be ground depends upon the skill of the operator, the best results cannot be obtained.

Chemical Pulp Mill

There have been a number of mills located at places where no hydraulic power is available. Transportation facilities for the supply of materials used in the manufacture, and the marketing of the finished product, are also large factors in the location of a plant of this kind. The plant requires in addition to the two cords of wood per ton of pulp made, sulphur, coal and lime, amounting in weight to over one-half a ton for each ton of pulp made.

The power requirements of the sulphite pulp process may be obtained by referring to Diagram No. 3, and to the following table:—

Apparatus	Approx. H.P. hours required per ton	Performance of apparatus
A. Wood Conveyor...	4 to 8	Delivering wood to plant
B. Chipper.....	16 to 24	Reducing blocks to small chips.
C. Screen.....	1 to 2	Sorting wood chips.
D. Chip Conveyor....	3 to 6	Delivering chips to bin
E. Chip Bin.....	....	Storing wood chips.
F. Digester.....	....	Reducing wood to pulp.
G. Wash Tank.....	....	Washing pulp.
H. Stock Tank.....	2 to 5	Storage of washed pulp.
I. Circulating Pump	30 to 60	Lifting diluted pulp.
J. Coarse Screen.....	1 to 3	Separating knots from fibre.
K. Fine Screen.....	14 to 25	Separating fine from coarse fibre
L. Wet Machine.....	25 to 35	Separating water from pulp.
M. Knot Reducer....	(not considered)	Reducing knots etc. to low grade pulp.
N. Acid Making.....	48 to 72	Making and delivering acid digester.
	144 to 240	6.0 to 10 H.P. per 24 hours.



From the first cost of such a plant as shown on Diagram No. 1 it is apparent that in view of the small amount of power required, no economy would be effected by using only restricted power.

Such an installation requires in addition to motive power, heat in the digester, shown in Diagram No. 3, under letter "F", where the wood chips are boiled in a solution of sulphurous acid, under about 80 lbs. steam pressure. The amount of heat required varies considerably, depending on the method employed in the working of the wood. While this demand is very irregular it is assumed in general practice that boiler capacity sufficient to deliver hourly 1,000 lbs. steam per ton capacity of plant per 24 hours is necessary. From this it will be seen that at a moderate price of coal the motive power required can be produced by a slight allowance in the capacity of the steam plant.

Large quantities of water are required in the manufacturing process, and the water should be comparatively clear as any impurities carried in it are likely to remain in the pulp and thus affect the value of the finished product.

The power consumption required for the water supply has not been considered as it would depend entirely on local conditions.

Paper Mill

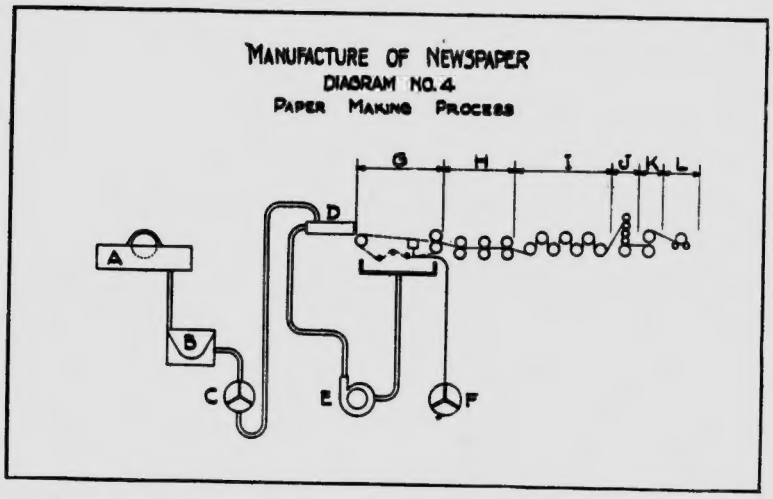
In so far as the writer is aware, no news-paper mills have been built close to the point of consumption in Canada, but in countries which import the raw materials for the manufacture of paper, mills have been

built in proximity to large towns. In Canada all the mills making news-paper produce their own ground-wood pulp, and quite a few of them also make their own sulphite pulp. There is a decided advantage in combining the three processes, viz.:—ground-wood, sulphite pulp and paper mill, while such a plan results in a somewhat lower first cost of the plant, its main economy is in the manipulation of the raw materials.

A news-paper mill may be located at any place having good transportation facilities for the supply of raw material and for disposing of the finished product. Since in this class of manufacture, a more highly skilled grade of labor is necessary than in the production of pulp, the location of the mill with reference thereto must also be considered, especially as a low efficiency of the labor may very much increase the cost of production.

The power requirements may be followed by referring to Diagram No. 4, and following table:—

Apparatus	Approx. H.P. hours per ton finished paper	Approx. ratio of product to water when leaving apparatus	Performance of apparatus
A. Beater or refiner...	70 to 120	1:25 to 1:14	Preparing paper fibre.
B. Stuff chest.....	3 to 5	"	Reservoir for paper fibre.
C. Stuff pump.....	2.5 to 5	"	Pump to elevate same.
D. Stuff screens.....	8 to 15	1:250	To remove impurities.
E. Circulating pump..	10 to 22	1:250	Circulate water used in formation.
F. Vacuum pump....	10.5 to 21.0		To remove water from paper web.
G. Fourdrinier part...	140 to 180	1:7	Formation of paper web.
H. Wet presses.....		1:2.3	Mechanical removal of water.
I. Dryers.....		Dry	Thermic removal of water.
J. Calenders.....		"	Polishing paper web.
K. Reels.....		"	Reeling paper web.
L. Rewinder.....	8 to 16	"	Cutting paper web.
	252 to 384 H.P. hours—10.5 to 16 h.p. for 24 hours.		



Power for items G to K is preferably supplied by the steam engine, using the exhaust steam in the dryers.

The dryers, item "I", require approximately 3 lbs. saturated steam at 0 to 10 pounds pressure per pound of paper made on the machine.

The steam engine driving the machine in a number of installations is made to drive all items above listed, except (A) the beater or refiner. By doing so, too much exhaust steam is generally produced, causing considerable waste of heat.

It is preferable to instal individual electric or group drives for all items except "G" to "K" inclusive. When the cost of motive power is low, there is some economy in driving all parts by electric motors, but it is very essential for the machine part proper (items "G" to "K" inclusive) to be connected to a circuit causing no variation of speed on the motors.

On machines operating at over 600 feet paper speed per minute, a sudden variation of one per cent. (1%) may cause the paper to break.

From the above it is apparent that a minimum 112 H.P. hours are required for the preparation of fibre and the driving of auxiliary apparatus in connection with the paper machine. Power requirements are, therefore, not so important a factor in the location of the paper mill but that preference may be given to close proximity to the market for the finished product.

The steam plant of the paper mill must be proportioned to take care of the large amount of heat required for ventilating the building. For every pound of paper made, about 2.3 pounds of water are removed from the paper web at the dryers, which is converted into vapor, and must be carried off by the ventilating system.

Considering the temperatures encountered in Canada, the amount of heat required for ventilating a paper machine building may at times be as much as eighty per cent. of the heat needed for drying the paper on the machine; the factors determining this are the temperature and relative humidity of the atmosphere.

Temperature has an appreciable effect on the manufacture of paper; large quantities of water are required in the process, and some of the water has to be raised to suitable temperatures in cold weather.

The water supply has also to be carefully considered in the location of paper mills, since there are employed various chemicals in the making of the paper, and unless the chemical characteristics of the water are given due consideration, there may result a large waste from that source.

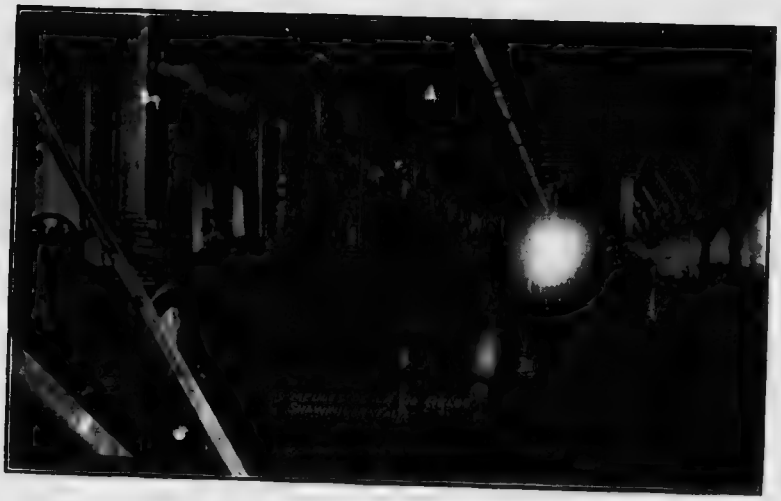
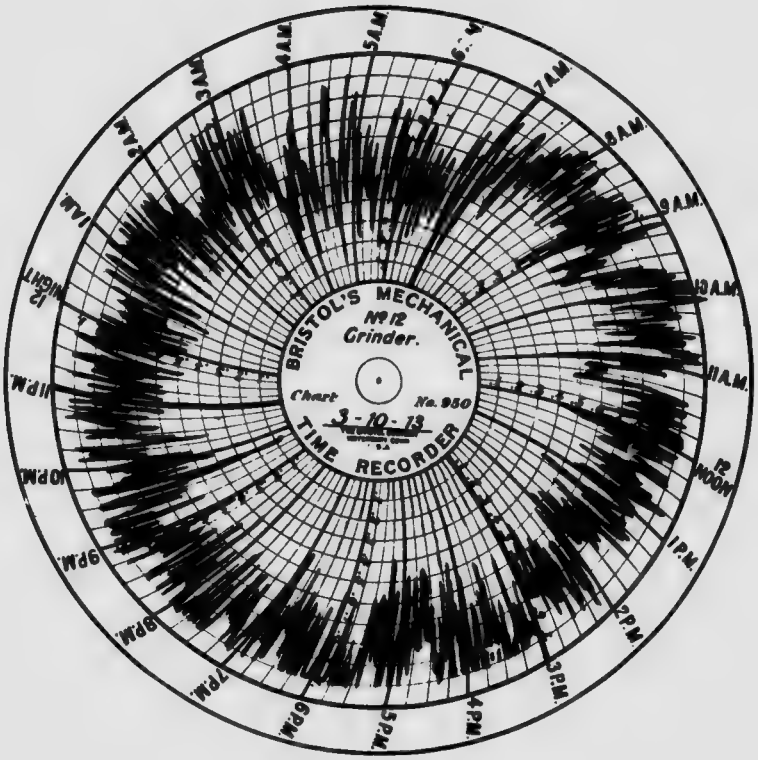


Fig. No. 1

Fig. No. 2

Fig. No. 3

Fig. No. 4


BRISTOL'S MECHANICAL
No 12
Grinder.
Chart
No. 950
3-10-13
TIME RECORDER
MIDNIGHT
1 A.M.
2 A.M.
3 A.M.
4 A.M.
5 A.M.
6 A.M.
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7 P.M.
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9 P.M.
10 P.M.
11 P.M.
12 MIDNIGHT

amount of contained pyrite. The crystalline limestone occurs as interstratified beds in the gneiss, and forms the highest portion of the Grenville series proper.

The graphite here occurs in several ways:

1. As disseminated flake in the limestone and gneiss and sometimes in the quartzite, pyroxene and even in masses of iron ore as at the Hull iron mines;

2. As lenticular or disconnected masses embedded in the limestone, or near the contact of this rock with eruptive masses, or partly in the limestone and associated gneiss. Sometimes the mineral is in the form of flake but is often associated with considerable deposits of the amorphous variety;

3. In the form of true fissure veins which traverse the gneiss and sometimes the intrusive granite or other eruptive rocks. The mineral in these cases is of the columnar or foliated variety.

Beneficial effect of intrusive rocks.

The beneficial effect upon the presence of graphite exerted by the agency of intrusive rocks was evident during the examination of many of these deposits by the writer in 1893, when it was seen that in all the mining areas this feature was conspicuous. In all cases where there were large bodies of disseminated ore in the gneiss or limestone such were usually closely associated with masses of granite or diorite. From notes furnished me by Mr. H. P. Brumell who was engaged in the graphite industry of the Buckingham district for some years it is evident the same conditions are seen on the property of the North American Graphite Co. He says of the rocks on lot 28, range VI, Buckingham, that "a series of parallel bands of graphitic gneiss are cut without any throw by a diorite dyke about 50 feet wide which cuts the strata at right angles. To the north of this main dyke is a reticulating system of small diorite eruptions in the neighbourhood of which the beds of ore are materially enriched. Again about 40 chains to the north of the above and in the pits near the mill of the company there occurs an apparent overflow of diorite beneath which cap the richest ore was found. And it may be stated in a general way that where the graphite gneisses are cut by dykes the percentage of graphite is much higher than elsewhere."

Economic production.

In regard to the economic production of graphite, while as already mentioned many of the fissure deposits are of great purity, the uncertainty of these occurrences is against their profitable exploitation on the large scale. Certain of the veins sometimes reach a thickness in places or between one and two feet, but these large veins are usually

Vein deposits.

short and soon split up into small ones or die out entirely. Amo
localities where this pure graphite appears to be most abundant, is t
property of the Walker Co., where near the line between ranges V
and VIII on lots 21-22, Buckingham, in several of the pits there occu
veins ranging in thickness from a few inches up to a foot and a hal
which have been worked to some extent. Vein graphite is also found
on lot 27, range V, in three veins disclosed in a pit, having a thickness
of from six inches to two feet. On lots 15-16, range VI, the vein
variety also occurs, and on lot 23, range V.

Disseminated flake of greatest economic importance.

The most persistent of the graphite deposits however are those which are found as disseminated flake. In the Buckingham district this variety is found usually in the grey mica gneiss in bands or beds which sometimes have a thickness of from ten to fifteen feet, or in places even more as well as in limestone. In some of these beds the graphite is very thickly distributed and the rock is quite black from its presence, indicating a high percentage of the mineral. Several assays were made by Dr. Hoffmann in the Survey laboratory some years ago which were published in the report for 1876-77 and are as follows: —

A specimen of disseminated ore from lot 28, range VI, Buckingham, owned by the Montreal Plumbago Co., the sample being regarded as a fair average of one of the largest and most extensively worked beds in the area with a breadth of eight feet, gave by assay, graphite 27·518 rock matter, 72·438 per cent. A sample from lot 22, range VI, Buckingham Mining Co., gave graphite 22·385, rock matter, 75·875 per cent. Specimens from lot 20, range VIII, gave graphite 23·798, rock matter 75 026 per cent; and from lot 23, range VI, graphite 30·516, rock matter, 69·349 per cent. In all the above occurrences the amount of disseminated ore appears to be large, and in some the presence of the vein variety is also recognized.

It must not be supposed that all the disseminated ore occurs in beds equally as rich as those just mentioned, but at very many points deposits exist which give amounts of flake from large bodies of ore, which range from 10 to 15 per cent or even higher. These ore beds are quite the equal in richness of any of the deposits worked in New York state.

Other vein deposits.

In addition to the vein deposits already mentioned as occurring in Buckingham, others are found in the Augmentation of Grenville, on lot 3, range II, where there is a reported vein 10 inches thick with disseminated ore, and on lot 1, range VI, as well as at other places in this area. The percentage of graphite from these deposits was found on assay to range from 97.626 to 99.815, thus shewing a

degree of purity quite equal to that found in the best Ceylon or Ticonderoga ore. Concerning the value of the prepared graphite, Dr. Hoffmann states that "in respect to incombustibility the Canadian graphite mayclaim perfect equality with that of the Ceylon; and that, apart from any consideration of proportion and nature of the associated foreign matter, it is in no wise inferior to the latter as a material for the manufacture of crucibles." Regarding the disseminated variety he also says in discussing this subject, that "prepared according to the present process the dressed graphite obtained from beds of disseminated mineral, is apt to contain more or less carbonate of soda and oxide of iron." He however points out that these can be easily removed by a simple process and the graphite be left "with a very small amount of ash, and that of a nature in no wise prejudicial to its application for the purposes under consideration." Rep, 1876-77.

Market affected by uncertain quality of product.

Discussing the nature of these deposits, Mr. J. Fraser Torrance, who spent some months in the graphite district in the study of apatite and other minerals, remarks that the bad reputation of the Canadian graphite on the market abroad is due to the uncertain quality of the article shipped, (Rep. 1882-83, p. 31 J.,) and to the fact that it contained certain impurities pointed out by Dr. Hoffmann as easily removable, but which had not apparently been done by the company that worked the mine: in other words that while certain portions of the mill product were of excellent quality, this excellence was not maintained throughout, so that the purchaser was uncertain as to the exact nature of the material purchased, and in consequence the market demand speedily ceased. In point of fact this statement appears to be clearly borne out in the history of all these mining operations which have been carried on at intervals for many years, since while all authorities are agreed as to the excellent quality of the ore, and to its abundance at many places, the loss of a permanent market has always been attributed to a lack of care in its preparation and proper purification.

Early history of graphite mining.

The early history of graphite mining in the Buckingham district dates back for about 40 years. The first mill of any importance appears to have been erected by the Lochaber Plumbago Co. on the Blanche river, lot 28, range X, Lochaber. The mill was run by water power, and was supplied with a battery of eight stamps and two circular buddles. The ore was stamped in water, and then passed over the buddles and afterwards through the stones and screens, but this part of the process was kept secret. The ore was obtained from several, points in the vicinity and principally from lot 24, range VIII, and lots 23-24, range XI. The ore beds were apparently in crystalline

limestone with bands of gre gneiss, through which were numerous veins irregularly distributed at or near the contact with a heavy dyke of granite, and the thickness of the ore bands was reported to range between 20 and 30 feet, while some of the veins had a breadth of 14 inches. A shaft was sunk on the ore body and several large trenches were made, so that a large amount of ore was raised and sent to the mill which from the first named lot is given as 620 tons (Rep. 1866, pp. 22-23.) On lots 22-23, the mineral occurred as the disseminated variety in a crystalline limestone which in places was black from the abundance of the graphite. The ore bed was reported as from 10 to 12 feet thick, and was worked by open cuts, the contained graphite being stated as about 20 per cent. This was mined to some extent and about 150 tons of the ore were sent to the mill for treatment. Operations have been suspended for many years, and when the locality was visited in 1893, the ruins only of the mill were to be seen.

Two other mills were erected in the early days of the industry, of which one was on the Garrett lot, (on McNaughton Creek), about two miles east of Buckingham, and the third on Fernie creek which is a discharge from the Twin lakes. This last was burned down but the other was abandoned and gradually fell to pieces by decay. No details as to the working capacity of these mills are available.

Walker Mining Co's mills.

These old mills have been supplanted by three new ones which have been in operation at intervals for some years. Of these the mill of the Walker Mining Co., on lot 19, range VIII, Buckingham, appears to have been the first erected about 20 years ago, but the original mill was abandoned and a new one put in operation in 1888 which worked at intervals to 1895, since which time it has practically been idle. The mill was well equipped with crushers, stamps, buddles, stones and screens, worked by a steam engine of 100 horse power, and with a reported capacity of 20 tons of raw material per day of 24 hours, or about three tons of the finished product.

The second mill is on the property of the Buckingham Mining Co. (Pugh & Weartz), lot 26, range VI, and has been in operation at intervals for some fifteen years. The mill of the North American Graphite Co., was erected in 1895, and though largely experimental is said to have a capacity of about two tons of the finished product per day.

The mills of the Walker Co., and of the last named, employ the wet method in the treatment and separation of the graphite, but in the other mill the dry process is employed. This has worked only fairly well, but the details of operation are not available. A modification of this plant is now in operation at the mills of the McConnell mine near

Olivers Ferry, Ont., and the process there is stated to give satisfactory results.

In the wet process the raw material after passing through the crushers goes to the stamp battery where it is crushed in water. Thence it passes to the buddles, then to the millstones, and is finally separated in a series of screens by which the separated flake is graded for the market. In the mill of the North American Graphite Co., lot 28, range VI, an improvement was introduced in the buddling process by which it is claimed greater efficiency is attained by the use of the Brumell separator, whereby a very close separation is achieved at once by the flotation of the dried graphite ore upon the surface of a current of water. After concentration, the method employed is the same as that in use at most of the other mills on the continent, viz., by buhr stones and screens. The product is high grade flake and low grade ground stocks. Details wet [illegible]

All these mills operate on the disseminated graphite, mostly from that contained in the greyish gneiss, and the columnar form is not considered as being in sufficient quantity to warrant the erection of commercial plants for its treatment owing to the uncertainty attending the deposits of this variety.

From the experience obtained from the running of several plants it has been clearly established that for all purposes which graphite is usually applied, with the exception of fine pencil making, the graphite so obtained has been proved eminently suitable. It has also been demonstrated that in properly constructed mills, and with proper care, a very high grade of graphite can be produced from the disseminated ores of the Ottawa district, as is evidenced from the analyses of the finished products made by different reliable assayers.

Much information relating to the extent and richness of the many graphite deposits in this province is given in the earlier reports of the Survey, more especially in the Geology of Canada, 1863, and in Vennor's report for 1873-74, pp. 139-143. In Vol. X, 1897, (pp. 66-73 S.) a very full description is given of the numerous deposits in the Buckingham district, prepared by Mr. A. A. Cole for the Geological Survey, shewing the extent of the ore bodies and the amount of development work done. This is accompanied by a reliable map of the area on which are placed all known outcrops, mill locations, and other points of general interest. Information contained in earlier reports of Geological Survey.

Graphite in Province of Ontario.

Graphite in Ontario.

The presence of graphite in certain rocks in Ontario was recorded as early as 1846 in Logan's report for the year. The locality first noted was in the township of Westmeath on lot 21, range A., front, near the Ottawa river, the mineral occurring in crystalline limestone, but no work has apparently ever been done here to determine the extent of the deposit which is probably not large.

In Murray's report on the district north of Kingston, 1852, the occurrence of a small vein of only one inch in thickness is reported on Mud lake, township of Loughborough, where it cuts the gneiss of that locality, but this may evidently be regarded as of no economic value.

Referred to in the Geology of Canada.

In the Geology of Canada, 1863, reference is made to its occurrence at several points, among which may be mentioned lot 6, range IX, Loughborough, where it is found in as a bed in limestone with a thickness of from three to eighteen inches, mingled with vitreous quartz, in which portions of pure graphite are imbedded; and on lot 18, range IX, Bedford, also in crystalline limestone, as well as at Bird lake, where it occurs in quartz with crystalline limestone. At neither of these places do the deposits appear to be extensive.

Since the date of these earlier reports deposits of graphite have been found at a number of places, some of which are large and of great commercial importance. In the Report by H. G. Vennor, 1872-73 mention is made of one of these in the township of North Elmsley, lot 21, range VI, about one mile north of Olivers Ferry on the Rideau canal. This was opened and has been worked at intervals by different people for more than thirty years, and at this place probably the first attempts at graphite mining in this province were made.

Important deposit near North Elmsley.

The mineral here occurs in crystalline rocks of the Grenville series, similar in character to those which have been already described in the province of Quebec. At the principal openings the old rocks are capped by horizontal beds of Potsdam sandstone. Where first opened up the graphite was found in a sandy greyish and somewhat decomposed gneiss, quite rusty in places, with beds of quartzite, underlying the crystalline limestone, and the graphite was well disseminated through a belt of considerable extent. The rocks here show the presence of a low anticlinal with low dips to the north-west and south-east.

The earlier mining at this place was carried on the gneissic portion of the formation, and the output was hauled to the shore of the canal,

about one mile distant, where a mill for the separation of the mineral was erected in 1872. This was equipped with stamps, buddles, and sieves or screens, and several grades of the separated flake were produced, of which the finest was used for electrotyping, a second for lubricating purposes, a third for pencil stock, a fourth for stove polish, and a fifth for foundry facings. The amount of mineral in the rock at the mine was held to run from 10 to 20 p[illegible], and was taken from a pit 300 to 400 feet long by 200 fe[illegible]ith a depth of about 20 feet. After working for several ye[illegible]e mill was apparently closed down in 1875 76.

Worked by Mr. J. Fraser Torrance.

The property was later worked for a time in 1893 by Mr. J. Fraser Torrance, but this was apparently not attended with much success owing to reasons not stated. The details of the first company's operations are given at length in the Report of the Bureau of Mines, Ont. for 1896, (pp. 35-36).

The property apparently lay idle till 1901 when Dr. R. A. Pyne of Toronto secured the diamond drill of the Ontario Government and bored several holes to test the depth and extent of this deposit. In this work four holes were sunk to the depths respectively of 130, 140, 64, and 100 feet. The borings shewed the presence of graphite of good quality and in large quantity. In the first boring the log showed 32 feet of graphite, the remainder of the hole being in an altered granite and limestone to the full depth of the hole; No. 3 shewed two feet of altered granite mixed with graphite, the remainder of the hole being in limestone; and in No. 4, there was found 30 feet of rich ore, the rest being lean. The nature of the "altered granite" is not stated and it may include certain of the bands of gneiss usually associated with the limestones of the formation.

Property secured by Mr. Rinaldo McConnell.

No attempt at mining is recorded by Dr. Pyne, but the property was secured shortly after by Mr. Rinaldo McConnell of Ottawa who also tested the property with the government drill preparatory to mining, which was commenced in the spr[illegible]g of 1902, the value of the property having been well asc[illegible]ained and the presence of large ore bodies determined, which in gr[illegible]phite content compare very favourably with those which have been [illegible]n the Buckingham district of Quebec. Surface shewings w[illegible] also found on lot 22, range VI, Burgess, but the actual value is n[illegible]t known.

The work of Mr. McConnell includ[illegible]e erection of a mill at the village of Port Elmsley, or rather the alteration of an old grinding mill which had been built at that place on the River Tay, some years before. Here there is a water power with a seven foot head which furnishes, with a Dodge turbine, about 50 horse power.

Mining operations.

Mining began at once, and when visited in Sept. 1903 there was an excavation of about 250 feet in length with a width varying from 8 to 14 feet and a depth from 10 to 15 feet. The old workings were abandoned and the new mine is several hundred yards to the south-west, situated on a bed of limestone which overlies the gneiss. This limestone contains thin rusty bands of sillimanite gneiss, and both are strongly charged with flake, some of the layers being quite black, so that the original composition of the rock is scarcely recognized. The dips are generally from 5 to 10 degrees, but at the north east end of the main trench the strata are inclined sharply to the north-west at an angle of 40 degrees. The openings are made along the low crown of the anticline, and no granite was seen on the surface at the mine itself, but there are small outcrops of a rather coarsely crystalline gabbro in the immediate vicinity. Granite ledges, however, show a short distance south-east of the pits and have been cut in the borings. The graphite appears to be all of the disseminated variety and no veins of the columnar were noticed. In the bottom of the trenches the ore seemed to be quite as rich as near the surface.

Treatment of ore.

The ore which is at present mined in the limestone, after being hauled to the mill a distance of nearly three miles, is first roasted in an ordinary kiln, sufficiently to drive off the contained moisture, but not enough to calcine the rock itself From the roaster it passes on a short track to the crusher, where it is broken to a uniform half inch-size, two sets of crushers being used. Thence it passes through a series of steel rolls which further reduce the ore to $\frac{1}{16}$ inch size. Then to the jigs which are of the pneumatic type, four in number and from the jigs the separated ore passes to the millstones where it is ground; and passing thence to the screens, it is there separated into four grades. The process of separation is apparently by the dry method throughout, and the whole routine from the preliminary roasting to the final bolting is automatic. The present capacity of the mill is about one ton and a half per hour, and the yield of graphite from the rock is placed at about 10 per cent. The dry process in this plant is claimed to work very satisfactorily. The mill is located a mile and half from Elmsley station on the Canadian Pacific railway.

Borings.

In the investigations on this area by Mr. Torrance, in 1893, borings were also made at a number of places on lots 21 and 22, range VI. and one on lot 23 of range VII. These borings reached depths of from 50 to 100 feet and the presence of the graphite bearing rock was reported as continuous to the bottom of the test holes while in some of the cores the mineral apatite was found.

Deposits of graphite were observed in 1896 in the township of Blythfield on lots 13 and 14, range IV, near the bank of the Madawaska river, a short distance above the High Falls, on land owned by Mr. James Bailey. These were opened to a small extent, and the mineral occurs in a greyish rusty gneiss associated with granite and greenish-grey pyroxene. The disseminated ore is partly flake and partly amorphous. The gneiss is in places highly garnetiferous and no limestone was seen at the locality where the graphite is exposed. Other deposits.

Among other places where the presence of this mineral is recorded in Ontario may be mentioned lot 13, range VIII, township of Marmora, where it is said to occur in considerable abundance, though no record of development work is to hand. The graphite from this place was examined in the laboratory of the Geological Survey and is of the amorphous variety, containing a small amount of finely disseminated pyrite, and gave on analysis, graphite 72·13, foreign matter, 27·86 per cent. Annual Report, Geol. Surv. Can., Vol. VII (N.S.) 1894, p. II R.

It has also been reported as occurring in the township of Faraday, on lot 13, range I, and by Dr. Barlow in the townships of Dysart and Glamorgan, where it is somewhat widely distributed in the limestone and upper gneiss of the Grenville series, (Summary Report, 1896, p. 53) but apparently no development work has yet been attempted in this area.

In the township of Darling also a small deposit of the amorphous variety has been located near Tatlock, but the value has not been definitely determined, though from surface indications the amount of the mineral does not appear to be large.

In Addington county, township of Denbigh, on lot 34, range VIII, a deposit of graphite was located some years ago and samples were examined by this Department. The mineral occurred in layers and patches in a calcareo-siliceous gangue, and on assay was found to contain 51·67 per cent graphite. It appears to be of the amorphous variety. Deposit in Denbigh township.

Recently this property has been opened up by Mr. J. G. Allan of Hamilton, Ont., who has furnished me some notes as to the nature of the work lately done. Mr. Allan says operations were commenced about the beginning of December, 1902, and a number of tons were taken out that month. In 1903 the mine was worked for about five months and 150 tons mined. The shaft is about 45 feet deep and well timbered. The material is somewhat mixed with quartz, but runs Worked by Mr. J. G.

about 50 per cent graphite and is improving in quality at lower depths. There are two veins which are widening and look as if they would meet below.

The following is the result of assay of this ore by Thomas Heys and Son of Toronto.

Graphite	76·12
Silica	5·70
Ox. Iron	1·28
Carb. lime	16·20
Carb mag	0·70

A similar occurrence is found on lot 1, range VIII, of Ashby which is the lot adjoining on the west. At present shipping facilities are bad, as the distance to railway is between 30 and 40 miles, but there appears to be a considerable amount of good ore in this area.

Black Donald mine.

With the exception of the mine at Olivers Ferry and that just mentioned the only other property at present being operated is that known as the Black Donald mine in the township of Brougham on the west end of Whitefish lake the property of the Ontario Graphite Co. It is situated on lots 16, 17, 18 and 19, range III.

Work was done on this area in 1895-96, and when examined in August of the latter year had been suspended. The ore-body was apparently large and was uncovered along its course about south-west from the shore of the lake for about 150 feet, with an exposed surface breadth of about 10 feet. The rocks around the lake are largely crystalline limestone associated with rusty gneiss and masses of granite.

Nature of deposit.

The strike of the former is N. 55° to 60° E. with a south-east dip of 60 degrees. The graphite where exposed appeared to be in bed form, underlaid by a hard whitish granite or pegmatite composed of quartz and felspar, and the ore body occurred on both sides of the granite dyke, continuing out under the waters of the lake. Graphite scales were also observed in certain portions of the granite, but it did not seem to be largely disseminated in the gneissic portion. A certain amount of pyrite was seen along the contact of the granite in the altered portion of the gneiss.

The general impression as to the graphite at that time was that it formed a large body of fairly pure mineral well worth development.

This property was shortly after opened up extensively. A mill was erected in Ottawa to treat the ore chemically, owing apparently to the somewhat large amount of calcite which it contained, and the ore was

brought in from the mine for treatment. This mill was operated for some months and then closed down.

As to the mine development, the Ontario Graphite Co. began operations on a somewhat large scale, the details of which can be given from the reports of The Bureau of Mines of Ontario. Worked by Ontario Graphite Co.

Thus in the report for 1895, it is stated that the deposit has a length of 300 feet, and four cross cuts made at inter-vals of 50 feet shew widths of the vein or bed as respectively 12, 17, 18 and 24 feet. The place was bored with a diamond drill with the following result. One bore on the shore of the lake passed through 39 feet of graphite, succeeded downward by six and a half feet of mixed limestone and graphite; this again by 10 feet of graphite; then seven feet of mixed limestone and graphite, one foot and a half graphite and two feet felspar and quartz. In another hole further removed from the shore there was graphite 15 feet, graphite and limestone seven feet and graphite six feet. Section of bore hole.

The deposit is not homogeneous throughout. The calcite occurs in nests and irregular pockets or masses, but containing also irregularly disseminated graphite and minute scales of mica. The quality of the mineral is somewhat lowered by the presence of the calcite in such a degree as to render portion of the deposit useless. An assay by Dr. J. T. Donald of Montreal, gave graphite 84·12, but the percentage varies in different specimens from 49 to 85. The graphite has a greyish aspect, is very hard, and occurs both as flake and amorphous. It is partly embedded, in gneiss in the manner of a vein with a strike north-east and south-west. Deposit not uniform throughout

In the report for 1901, (Mining Bureau of Ont.) it is stated that the company known as the Ontario Graphite Co. was organized in 1896. The workings consisted of open cuts and a shaft 80 feet deep, with a drift to the north-east from the bottom of 150 feet which extended under the lake. The vein is vertical, and at the bottom has a width of 22 feet with enclosing walls of crystalline limestone. An analysis by the Crescent Steel Co. gave graphitic carbon, 84·06, silica, 3·90, lime 10·05.

In the report for 1902, Bureau of Mines), further details are given. The steam plant was replaced by an electric plant, operated by power generated at the Mountain Chute on the Madawaska river, two miles and a half south-east of the mine. This plant furnishes sufficient power for working the mine including lighting and heating, and for the graphite refinery which is erected close to the mine on the shore of the Steam plant replaced by electric.

lake. The main shaft is 10 x 12 feet, vertical, and 80 feet deep. The main level northeast was extended to 200 feet out under the lake and to the south-west for 24 feet. The former was stoped out 50 feet high for 120 feet, and 30 feet for the remaining 80 feet. The latter was stoped out 16 feet high for the full length, the stopes being from 8 to 22 feet wide or averaging 13 feet. A 20 foot collar extends down the shaft with a 50 foot open head frame.

Development.

South-west from the shaft the vein was located by an open cut for 135 feet, 12 feet wide and 39 feet deep. Fifty-four feet south of this is another open cut, 10 feet wide and 50 feet long; and 50 feet beyond this a vertical shaft was sunk to a depth of 49 feet. Beyond this cross cuts uncovered the vein for several hundred feet. In 1901 three diamond drill holes were sunk from the bottom of the 80 foot shaft, finding graphite at a depth of 122 feet from the surface, where a hard flinty rock stopped the further progress of the drilling.

The surface exposures shew the rock to be a white limestone in which the graphite vein or bed is located, with a thickness varying from seven to twenty-two feet, averaging about 14 feet of clean ore or graphite with 15 to 20 per cent of rock matter. For two to three feet back the walls are of schistose limestone, carrying thickly disseminated graphite flake. Beyond this the graphite is regarded as sufficiently abundant to make a milling ore over a width of 40 feet where worked. In the central portion the mineral occurs both as flake and in the crystalline form.

Development seriously affected by break in roof of mine.

In the autumn of 1902 a break occurred in the roof of the drift which extended under the lake so that the water with the marl which formed the lake-bed was admitted and flooded all the workings connected with the main shaft. This accident has, for a time seriously affected further development, but work has since been carried on the western portion of the deposit, the results of which have not yet appeared.

This place is distant from the Kingston and Pembroke railway at Calabogie by winter road about 12 miles, but the regular road is fully twice as long. About 2,200 tons ore were extracted in 1901, most of which was shipped.

Extent of ore body.

The amount of ore in sight [illegible] tension of the deposit west of the main shaft appears to be quite [illegible] ge as in the eastern or lake portion of the ore body, and in its extension from the west shaft is reported as having at one place a thickness of 46 feet, which however may be only a local development, The mine is well equipped with appliances

for raising and separating the ore and the output from the refinery is produced in nine grades, of which the first four are composed of flake or crystalline graphite of different sizes and with a purity of from 93 to 96 per cent carbon; the next is a mixture of flake and amorphous running about 78 per cent carbon; and the last four are amorphous powders of varying degrees of purity from 54 to 62 per cent. For details of mill, &c., see Bureau of Mines report, Ont., 1903, pp. 132-34.

Other occurrences of graphite are recorded, as in South Canonto on the second range, lot not mentioned, where a small amount of work has been done. Also on lot 2, range VI, Bedford; Dungannon, lot 28, XIII; Loughborough, lot 6, range IX; North Burgess, lot 10, range I; North Elmsley, lot 7, range IX; and at Parry Sound; see Minerals of Ontario, Bureau of Mines, 1900, page 199.

In regard to the western portions of the Dominion including the Rocky mountain area and Pacific coast slopes no records of graphite deposits of economic importance have yet been recorded.

Statistics.

Production.

The first records of production given in the Geological Survey Reports of the Section of Mines, are for the year 1886, the output for that year being stated as 500 tons with a value of $4,000. Since that date for about ten years the figures fluctuate and in 1893-4 the output was practically nil. There was a marked revival of the industry in 1895, and since that time the output has increased regularly to 1901, when it reached 2210 tons valued at $37,780. Owing to the closing of one of the principal mines for a time the output for 1902 declined to 1095 tons valued at $28,300.

The principal producers during the last year mentioned were the Canada Paint Co. of Fairville, N. B., the North American Graphite Co. of Buckingham, Que.; and the Ontario Graphite Co. of Ontario, operating at Whitefish lake, Brougham township.

The value of graphite in the crude and as manufactured imported in the year 1901 into Canada, was $77,893 as under.

Plumbago, not ground	$ 2,357
Black lead	25,346
Plumbago, ground and manufactured, crucibles, &c.	49,890
	$77,893

In 1902 this amount slightly declined, the figures being for

Plumbago, not ground	$ 3,649
Black lead	20,467
Plumbago, ground and manufactured, crucibles, &c.	43,656
	$67,772